Section 14
Crew Health Care System

14.1 Introduction

The Crew Health Care System (CHeCS) is required to maintain the health of the International Space Station (ISS) crew. CHeCS is composed of three subsystems, each of which meets one of three major health concerns associated with long-duration spaceflight. Multiple devices and supplies comprise CHeCS and are described in detail below.

14.2 Objectives

After reading this section, you should be able to

- Identify the purpose of CHeCS
- Identify the purposes of the three CHeCS subsystems
- Identify the key components available by Flight 8A

14.3 Purpose

The purpose of CHeCS is to enable an extended human presence in space by assuring the health, safety, well-being, and optimal performance of the ISS crew.

14.3.1 CHeCS Architecture

CHeCS components will arrive on ISS in three phases, with a few exceptions. A selection of hardware is manifested to support the Increment 1 crew (launched on Flights 2R, 2A.1, and 3A). The second phase is the launch of the first CHeCS rack, which will reside in the U.S. Laboratory Module (Flight 6A) until the U.S. Habitation Module arrives. The third phase is the launch of three CHeCS racks, which will reside in the U.S. Habitation Module (Flight 17A). At that point, CHeCS will be at its full compliment. See Section 14.8, CHeCS Launch Summary/Appendix, for CHeCS launch summary.

CHeCS consists of both rack-mounted and portable components. The portable components are either stowed until needed or permanently deployed. Stowage requirements for each component are presented in the following sections.

14.3.2 CHeCS Subsystems

Three health-related concerns were defined early in the Space Station development process. These include physiological countermeasures to spaceflight, environmental monitoring, and medical care. The three CHeCS subsystems each address one of the concerns. The Countermeasures System (CMS) evaluates crew fitness, provides countermeasures, and monitors the crew during countermeasures. The Environmental Health System (EHS) monitors air and water quality for chemical and microbial contaminants, monitors radiation levels, and monitors surface microbial contaminants. The Health Maintenance System (HMS) monitors crew health, responds to crew illness or injury, provides preventive health care, and provides stabilization and emergency transport between vehicles.

14.4 Countermeasures System

The CMS prevents cardiovascular and musculoskeletal deconditioning that occurs as a result of exposure to spaceflight. We have learned from the Skylab, Space Shuttle, and Mir Programs the importance of physiological countermeasures to maintain muscle and bone mass and strength, and we have learned to prepare for re-adaptation to the 1-g environment after landing. Prescribed exercise is performed daily by all ISS crewmembers, except on the day of an Extravehicular Activity (EVA) or within 24 hours of a periodic fitness evaluation. Periodic fitness evaluations monitor the crewmembers' fitness level and determine if deconditioning has occurred. This allows the crew surgeon to alter exercise and countermeasure protocols, if required.

14.4.1 Components

The CMS consists of exercise hardware, including a treadmill, resistive exercise device, and cycle ergometer, and monitoring devices, including a portable computer, heart rate monitor, and Blood Pressure (BP) and Electrocardiogram (ECG) monitor.

14.4.1.1 Treadmill With Vibration Isolation System

The Treadmill with Vibration Isolation System (TVIS) is used to simulate 1-g walking and running. The TVIS is used primarily for postural and locomotor musculoskeletal maintenance, with cardiopulmonary benefits. The treadmill is very similar to the Extended Duration Orbiter (EDO) treadmill flown on several shuttle missions. The major differences include relocation of the restraints, addition of active or motorized capability, and addition of the Vibration Isolation System (VIS). The VIS minimizes vibration that might affect other ISS systems or payloads by isolating x, y, and z translation, roll, pitch, and yaw. A TVIS system similar to the ISS TVIS was flown on shuttle Flight STS-81. The TVIS allows a maximum translation of ± 0.5 inches and ± 2.5 degrees rotation in any axis and does not pass a load greater than 5 pounds to surrounding connections or structures. The restraints, or Subject Load Devices (SLDs), are located to the side of the crewmember (Figure 14-1), rather than forward and aft as with the EDO treadmill. Similar to the Mir treadmill, the TVIS is located in a pit within the Service Module, and the running surface of the treadmill is flush with the floor of the module. The display unit folds down when not in use. The treadmill operates in an active (powered) or passive (nonpowered) mode. The TVIS is launched on Flight 2A.1 and requires assembly on orbit. The TVIS will remain in the Service Module and is currently the only treadmill manifested for ISS.

Figure 14-1. Treadmill with vibration isolation system

14.4.1.2 Medical Equipment Computer

The Medical Equipment Computer (MEC) is the CHeCS Portable Computer System (PCS). The ***MEC provides for storage and downlink of exercise data from the ergometer and TVIS, physiological data such as electrocardiogram and heart rate, and EHS data*** (see Environmental Health System Components). The MEC also contains medical records, medical reference, and psychological support software.

14.4.1.3 Resistive Exercise Device

The Resistive Exercise Device (RED) prevents muscle atrophy of the major muscle groups by maintaining strength, power, and endurance. ***The RED provides resistance training for the major muscle groups*** of the legs, hips, trunk, shoulders, arms, and wrists. The RED is mounted to the Treadmill with Vibration Isolation System (TVIS) for isolation and to allow interval training protocols. Up to 430 pounds of resistance is available in increments of 5 pounds. Information, including set number, repetition number, and resistance load, is stored and viewed and/or downlinked via the MEC.

The following exercises can be performed with the RED:

- Squat
- Dead lift
- Bent rows
- Calf raises
- Leg extension
- Leg curl
- Knee lift
- Leg abduction
- Leg adduction
- Lateral raises
- Military press
- Chest/butterfly
- Biceps
- Triceps
- Side bends

14.4.1.4 Heart Rate Monitor

The heart rate monitors are heart watches that can be worn by the crew to monitor heart rate and control exercise level during daily exercise (Figure 14-2). Heart rate is measured accurately, continuously, and noninvasively. The heart rate transmitters are the same as flown on the space shuttle, with the heart rate receivers located on the treadmill, ergometer, and available on a watch.

Figure 14-2. Heart rate monitor

14.4.1.5 Blood Pressure/Electrocardiogram Monitor

The Blood Pressure/Electrocardiogram (BP/ECG) monitor is used to monitor and record systolic and diastolic blood pressure (in mmHg), ***heart rate, and 12-lead ECG waveform*** on a continual basis during periodic fitness evaluations and microgravity countermeasures. The information is downlinked to the flight surgeon in the Mission Control Center (MCC) for monitoring during the periodic fitness evaluations via the Medical Equipment Computer (MEC).

14.4.1.6 Cycle Ergometer With Vibration Isolation System

The cycle ergometer is used for systemic aerobic conditioning and can be used to perform independent upper and lower limb cycle activity. The cycle ergometer is located in the Lab and is shared by Crew Health Care System (CHeCS) and the Human Research Facility. The device is similar to the space shuttle Inertial Vibration Isolation System ergometer (Figure 14-3), with modifications made only to the electronics of the system. As with the TVIS, the Vibration Isolation System (VIS) isolates x, y, and z translation, roll, pitch, and yaw.

Figure 14-3. Space shuttle cycle ergometer

14.5 Environmental Health System

The Environmental Health System (EHS) provides qualitative and quantitative air, water, surface, and radiation monitoring for the internal and external environments of the ISS. Close environmental monitoring is crucial to ensure a safe, clean atmosphere for the crew to live and work. The EHS provides the hardware to monitor aspects of the ISS environment essential to crew health.

14.5.1 Components

The EHS hardware is divided into four groups, representing the four areas that are monitored: Water Quality, Microbiology, Radiation, and Toxicology.

14.5.1.1 Water Quality Hardware

Total Organic Carbon Analyzer

The Total Organic Carbon Analyzer (TOCA) determines the concentration of total carbon, total inorganic carbon, and total organic carbon in ISS potable water samples, as well as pH and conductivity (Figure 14-4). A full analysis is conducted in 30 minutes or less. Results are read from the TOCA display and/or stored and downlinked via the MEC. Following Flight 6A, the Total Organic Carbon Analyzer (TOCA) will be stowed in the CHeCS rack. Water is sampled weekly in the Service Module for the first 90 days of Increment 1 and monthly thereafter.

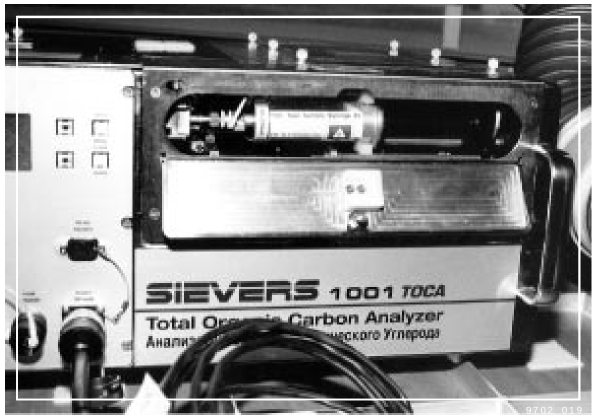

Figure 14-4. Total organic carbon analyzer

Water Sampler and Archiver

The Water Sampler and Archiver (WSA) is used to collect and store ISS water samples for in-flight and ground-based analysis. The kit contains water sampling and calibration syringes, archival sample bags, and sample collection adapters for obtaining samples aseptically. The Water Sampler and Archiver (WSA) is portable and stowed in the CHeCS rack when not in use.

14.5.1.2 Microbiology Hardware

Water Microbiology Kit

The Water Microbiology Kit (WMK) detects and enumerates microorganisms in the onboard water systems. The kit consists of a syringe pump assembly, microbial capture devices, air filter assemblies, liquid media, and sample and waste bags (Figure 14-5). After collection, water samples are drawn through the microbial capture device, which filters the water and captures microorganisms (Figure 14-6). Data from the Water Microbiology Kit (WMK) includes total count (colony forming units) and fecal coliforms. Results are read at 2 days and 5 days after inoculation of the microbial capture devices.

Figure 14-5. Water microbiology kit

Figure 14-6. WMK syringe assembly

Surface Sampler Kit

The Surface Sampler Kit (SSK) contains media for culture of microbial and fungal organisms from exposed internal surfaces. Samples are taken from two sites per habitable module, once per month for the first 3 months of Increment 1 and once every 3 months thereafter. Two types of contact slides with agar media are used, one type for bacteria and one for fungi (Figure 14-7). Slides are stowed after inoculation and evaluated at 2 days and 7 days for growth. Any resulting growth is compared to a density chart, and results are called down.

Figure 14-7. Surface sampler kit

Microbial Air Sampler

The Microbial Air Sampler (MAS) determines levels of airborne microbial contaminants in the habitable modules. The MAS kit contains a portable air sampling device used to collect air samples from ISS modules (Figure 14-8). Each module is monitored once a month for the first 3 months of Increment 1 and once every 3 months thereafter. Air samples are taken on two types of agar media plates, one plate for bacterial growth and the other for fungal growth. The incubation time is 48 hours for bacteria and 7 days for fungi. The crew compares resulting growth to density charts and calls down results.

Figure 14-8. Microbial air sampler

14.5.1.3 Radiation Hardware

Tissue Equivalent Proportional Counter

The Tissue Equivalent Proportional Counter (TEPC) measures and stores accumulated radiation spectra. The TEPC includes a detector and spectrometer (Figure 14-9). During Increment 1, the TEPC interfaces with the MEC for data storage and downlink. After Flight 5A, TEPC data is transferred via the CHeCS 1553B bus for telemetry to the ground. The TEPC uses ISS power and must be connected to a CHeCS designated power/data port for data downlink. The TEPC operates continuously, requiring relocation by the crew weekly. The Tissue Equivalent Proportional Counter (TEPC) is secured to ISS nodes and modules via seat track fittings or Velcro.

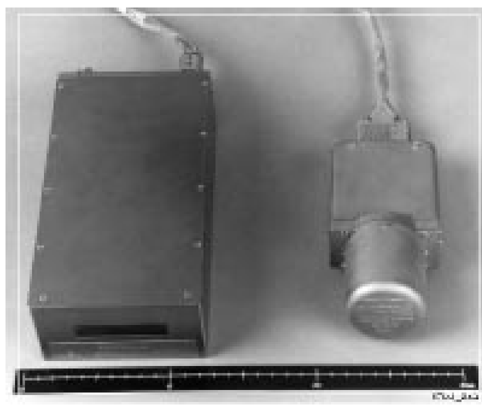

Figure 14-9. Tissue equivalent proportional counter

Personal Dosimeters

Personal dosimeters are worn continuously by each crewmember throughout the increment. Similar personal dosimeters are worn by space shuttle and NASA/Mir crewmembers. The small, passive dosimeters are analyzed postflight to determine the radiation exposure of the crewmember throughout the mission.

Radiation Area Monitors

Radiation Area Monitors (RAMs) are independent monitors attached throughout the ISS. A set of RAMs are deployed by each Increment throughout all habitable volumes, with four to six in each module and two to four in each node. Radiation Area Monitors (RAMs) are changed out with each crew rotation. The RAMs are small, passive dosimeters attached to walls and surfaces with Velcro. Results are read postflight to determine radiation levels throughout the ISS.

Intravehicular Charged Particle Directional Spectrometer

The Intravehicular-Charged Particle Directional Spectrometer (IV-CPDS) measures the flux of all trapped, secondary, and galactic cosmic rays as a function of time, energy, and direction internal to the ISS (Figure 14-10). Data from the IV-CPDS is transferred via the CHeCS 1553B bus for telemetry to the ground. The IV-CPDS is relocated by the crew weekly This may involve only rotating the instrument, since measurements are taken unidirectionally.

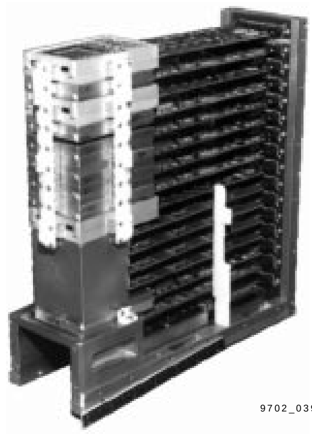

Figure 14-10. Intravehicular-charged particle directional spectrometer

Extravehicular-Charged Particle Directional Spectrometer

The Extravehicular-Charged Particle Directional Spectrometer (EV-CPDS) measures the flux of all trapped, secondary, and galactic cosmic rays as a function of time, energy, and direction external to the ISS. The EV-CPDS is composed of three Intravehicular-Charged Particle Directional Spectrometers (IV-CPDSs), each facing a different direction (Figure 14-11). The EV-CPDS is contained in an Extravehicular Activity/Extravehicular Robotics removable avionics box mounted to the S-0 truss. The EV-CPDS is mounted preflight and arrives on Flight 8A attached to the S-0 truss segment. An EVA is required to position the EV-CPDS properly. Data is transferred via the CHeCS 1553B bus for telemetry to the ground. The EV-CPDS is the only CHeCS component located external to the ISS.

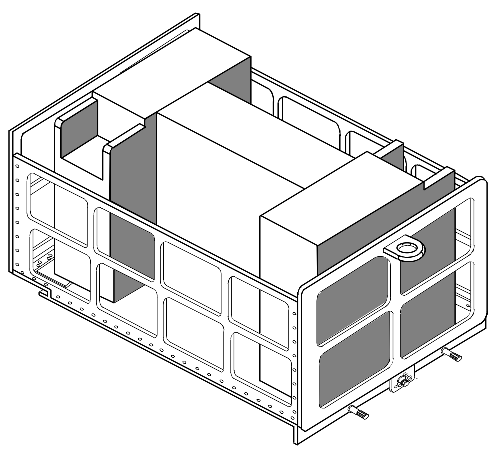

Figure 14-11. Extravehicular-charged particle directional spectrometer

14.5.1.4 Toxicology Hardware

Compound-Specific Analyzer - Combustion Products

The Compound-Specific Analyzer - Combustion Products (CSA-CP) detects, identifies, and quantifies concentrations of carbon monoxide, hydrogen cyanide, hydrogen chloride, and oxygen. Data is logged internally and displayed on the face of the unit. The CSA-CP can be used in the passive mode (Figure 14-12) or active mode using a pump attachment (Figure 14-13). Five primary scenarios have been identified for the use of the two CSA-CPs onboard.

- In the event smoke is detected, a CSA-CP is used to determine concentrations of combustion products during cleanup efforts.
- In the event a crewmember exhibits symptoms of inhalation exposure, a CSA-CP is used to sample the area of potential exposure and determine if combustion products are present.
- One CSA-CP is used in passive mode on a continuous basis, primarily to sample for carbon monoxide. If the response of any sensor exceeds the threshold concentration during passive monitoring, a local audio and visual alarm is annunciated to the crew.
- In the event of a Major Constituent Analyzer (MCA) failure, a CSA-CP is deployed and used in passive sampling mode for determining levels of oxygen.
- Following a combustion event, a CSA-CP provides information that indicates the effectiveness of contingency atmospheric cleanup procedures and if gas masks or portable breathing apparatus can be doffed.

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Figure 14-12. Compound-specific analyzer - combustion products

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Figure 14-13. CSA-CP with pump

Volatile Organic Analyzer

The Volatile Organic Analyzer (VOA) determines the concentration of targeted compounds in the ISS atmosphere. The VOA is used for periodic sampling of the atmosphere, and data is downlinked via the CHeCS 1553B bus. Target compounds and detection limits are listed in Table 14-1.

Table 14-1. Volatile organic analyzer target compounds

Compound	Detection limit (mg/m^3)	Compound	Detection limit (mg/m^3)
1,1,1-Trichloroethane	1	Dichloromethane	0.5
1,2,2 Trifluoro-1,2,2-Trichloroethane	5	Ethanal, (Acetaldehyde)	0.5
1-Butanol	5	Ethanol	5
2-Butanone	3	Ethyl Acetate	5
2-Butoxyethanol	1	Hexamethylcyclotrisiloxane	10
2-Methyl-1,3-Butadiene	10	Methanol	0.5
2-Methyl-2-Propanol	5	Methyl Benzene, (Toluene)	3
2-Propanone	5	n-Hexane	5
4-Hydroxy-4-Methyl-2-Pentanone	1	n-Pentane	10
Acetic Acid	0.5	Trichlorofluoromethane	10
Benzene	0.1	Trifluorobromomethane	10
Carbonyl Sulphide	0.5	Trimethylsilanol	3
Chlorodifluoromethane	5	Xylenes, (total of three isomers)	10
Dichlorodifluoromethane	10		

Compound-Specific Analyzer - Hydrazine

The Compound-Specific Analyzer - Hydrazine (CSA-H) is used in the airlock to detect hydrazine contaminating the Extravehicular Mobility Unit (EMU) after an EVA (Figure 14-14). The monitor is stored in the airlock during an EVA on which contamination is deemed a possibility, and it is activated by the EVA crew upon repressurization of the airlock. After activation, the monitor is moved over the outside surface of an EMU. If hydrazine is present, a display indicates the contaminant and its concentration. EVA procedures define the actions to be taken if hydrazine is detected. A datalogger is built into the monitor to verify and document detection of a contaminant.

Figure 14-14. Compound-specific analyzer - hydrazine

14.6 Health Maintenance System

The Health Maintenance System (HMS) provides preventive, diagnostic, and therapeutic care, as well as patient transport capability. The HMS is designed to supply daily needs and basic life support, as well as advanced life support for a crew of three for 180 days.

14.6.1 Components

The HMS is composed of six components, the Ambulatory Medical Pack (AMP) provides for daily needs and periodic health examinations, the Crew Contaminant Protection Kit protects the crew in case of a toxic spill or contamination, and the remaining four, including the Advanced Life Support Pack, Crew Medical Restraint System, defibrillator, and Respiratory Support Pack, provide for advanced life support and transport.

14.6.1.1 Ambulatory Medical Pack

The AMP provides in-flight medical care, such as basic first aid and treatment for minor illness or injury. The AMP includes daily use items such as oral medications, bandages, topical medications, and injectables (Figure 14-15). Also included are physician's instruments needed for comprehensive physical exams performed monthly on each crewmember. A Portable Clinical Blood Analyzer (PCBA) is also included in the Ambulatory Medical Pack (AMP). The PCBA requires only a finger prick and analyzes levels of various blood constituents. The AMP is resupplied every 6 months.

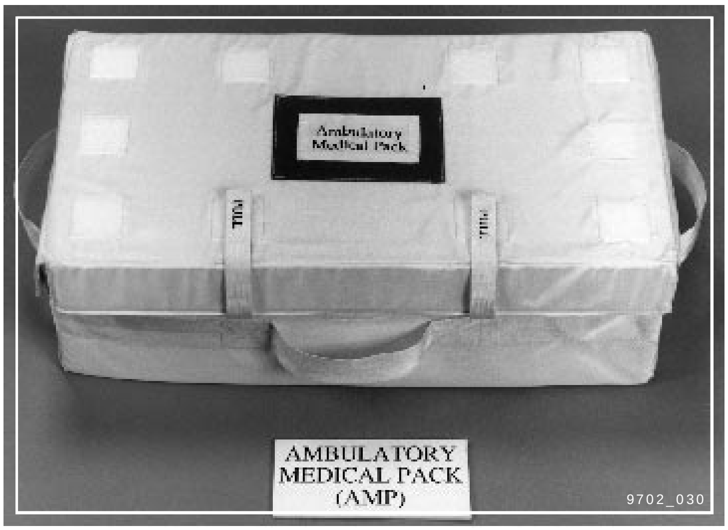

Figure 14-15. Ambulatory medical pack

14.6.1.2 Crew Contaminant Protection Kit

The Crew Contaminant Protection Kit (CCPK) is a multipurpose kit that protects the crew from toxic and nontoxic particulates and liquids (Figure 14-16). The CCPK is almost identical to the space shuttle contaminant cleanup kit. The major difference is the interface for the emergency eyewash system. The Space Station Eyewash (SSE) is a modified pair of swim goggles with tubing that allows a continuous flow of water to flush the eyes of contaminants. The SSE connects to the SVO-ZV port (Service Module drink port) for supply water and dumps contaminated water to 1.8-liter waste bags. The CCPK also includes goggles for eye protection, masks for respiratory protection, gloves for skin protection, multiple waste bags for containment, and decals for labeling the waste bags with the toxicity level of the contents. The CCPK is resupplied at the first available opportunity after use, or every 2 years.

Figure 14-16. Crew contaminant protection kit

14.6.1.3 Advanced Life Support Pack

The Advanced Life Support Pack (ALSP) provides advanced cardiac life support and basic trauma life support capabilities. Supplies in the ALSP are divided into subpacks by function (Figure 14-17). The following subpacks are included in the ALSP:

- Airway Subpack
- Drug Subpack
- Emergency Surgery Subpack
- Assessment Subpack
- Intravenous (IV) Administration Subpack
- Bandages Subpack

In addition to the subpacks, the ALSP contains an Ambu bag, blood pressure cuff, stethoscope, sharps container, IV infusion pump, and endotracheal detector device. The ALSP is resupplied at the first available opportunity after use, or every 18 months.

Figure 14-17. Advanced life support pack

14.6.1.4 Crew Medical Restraint System

The Crew Medical Restraint System (CMRS) provides restraint, with spinal stabilization, for an ill or injured crewmember, while also providing restraint for the Crew Medical Officers (CMOs) attending to the patient (Figure 14-18). The CMRS provides electrical isolation for the CMOs and the ISS during defibrillation. The CMRS is stowed in the CHeCS rack and attaches to the ISS via seat track interfaces. The design enables the CMOs to deploy the CMRS and restrain the patient within 2 minutes.

Figure 14-18. Crew medical restraint system

14.6.1.5 Defibrillator

The defibrillator provides for defibrillation, ECG and heart rate monitoring and analysis, and transcutaneous (external) pacing. The defibrillator, pictured in Figure 14-19, is a commercial-off-the-shelf device with the addition of a Power and Data Interface Module (PDIM). The PDIM allows downlink of the ECG and heart rate to the flight surgeon in the Mission Control Center-Houston (MCC-H). The defibrillator is stowed in the CHeCS rack with power and date lines connected. If the injured crewmember cannot be brought to the CHeCS rack, the defibrillator can be brought to the patient. The defibrillator can be powered from any UOP, but can downlink data only through a CHeCS UOP. The defibrillator includes two batteries for use during patient transport. Periodic on-orbit checkouts of the defibrillator unit by the crew are required.

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Figure 14-19. Defibrillator

14.6.1.6 Respiratory Support Pack

The Respiratory Support Pack (RSP) provides resuscitation for a crewmember with impaired pulmonary function. The RSP, shown in Figure 14-10, ventilates an unconscious crewmember automatically, with the Crew Medical Officer (CMO) preparing the settings; provides oxygen to a conscious crewmember who needs assistance breathing; and allows the CMO to manually resuscitate a patient. The RSP uses oxygen from the ISS O_2 bus, portable breathing apparatus bottles, or space shuttle oxygen ports. The RSP is pneumatically powered and, therefore, has no Electrical Power System interface. The RSP will be functional at Flight 7A, after installation of the oxygen supply tanks, and will be stowed in the CHeCS rack.

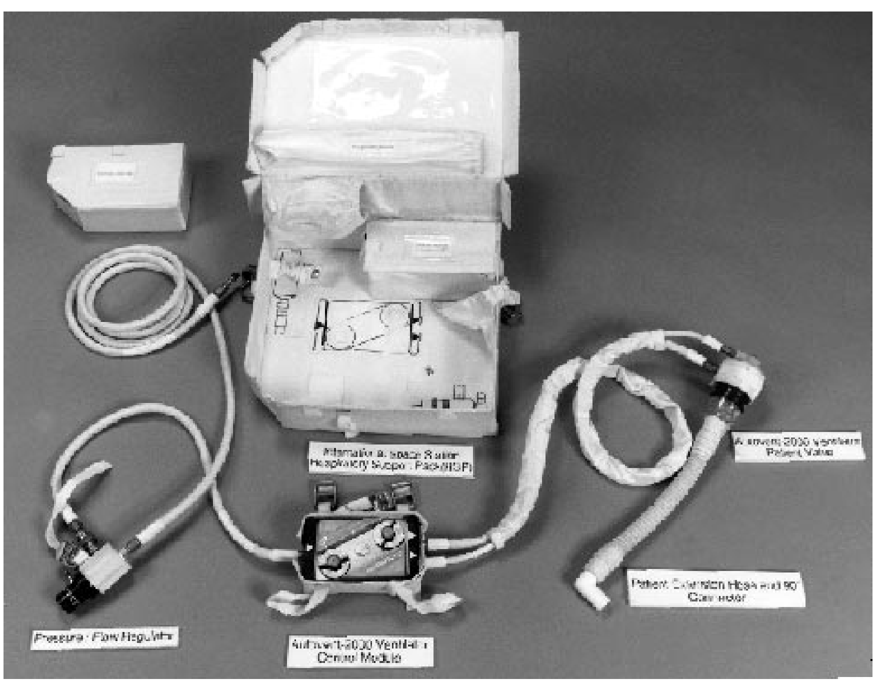

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Figure 14-20. Respiratory support pack

14.7 Summary

CHeCS, including the Countermeasures System (CMS), EHS, and HMS, enables an extended human presence in space by assuring the health, safety, well-being, and optimal performance of the ISS crew.

CounterMeasures System	Environmental Health System	Health Maintenance System
Treadmill with Vibration Isolation System	Total organic carbon analyzer	Ambulatory Medical Pack
Medical equipment computer	Water sampler and archiver	Crew Contaminant Protection Kit
Resistive exercise device	Water Microbiology Kit	Crew Medical Restraint System
Heart rate monitors	Surface Sampler Kit	Advanced Life Support Pack
Blood pressure/electrocardiogram monitor	Microbial air sampler	Defibrillator
Cycle ergometer with Vibration Isolation System	Tissue equivalent proportional counter	Respiratory Support Pack
	Personal dosimeters	
	Radiation area monitors	
	Intravehicular-charged particle directional spectrometer	
	Extravehicular-charged particle directional spectrometer	
	Compound-specific analyzer - combustion products	
	Volatile organic analyzer	
	Compound-specific analyzer - hydrazine	

14.8 CHeCS Launch Summary

Flight	CHeCS component(s)
2A.1	TOCA, heart rate monitors, TEPC, CCPK, TVIS, MEC, CSA-CP, BP/ECG monitor, SSK, WSA, RED
3A	AMP, ALSP
2R	Personal dosimeters, RAMs, HRDs
6A	CMRS, IV-CPDS, defibrillator, RSP, VOA, MAS, cycle ergometer
7A	CSA-H
8A	EV-CPDS
16A	Spectrophotometer
17A	Incubator, fungal spore sampler, slide staining apparatus

Questions

1. What is the purpose of the CHeCS?
   a. To resupply health care consumables during ISS operations
   b. To ensure the health, safety, well-being, and optimal performance of the ISS crew
   c. To provide health care and environmental monitoring
2. The purpose of the CHeCS Health Maintenance System (HMS) is to provide
   a. Preventive, diagnostic, and therapeutic care, as well as patient transport capability
   b. Preflight, in-flight, and postflight physical examinations to ensure crew health
   c. Complete advanced life support and rescue capabilities in a medical emergency
3. Which of the following CHeCS components will <u>not</u> be on ISS by Flight 8A?
   a. Defibrillator
   b. Incubator
   c. Medical Equipment Computer (MEC)
4. The purpose of the CHeCS Countermeasures System (CMS) is to prevent
   a. Crew exposure to radiation
   b. Contamination of the internal ISS environment
   c. Cardiovascular and musculoskeletal deconditioning

5. Which of the following CHeCS CMS components will not available by Flight 8A?

   a. Treadmill with Vibration Isolation System (TVIS)

   b. Blood Pressure/Electrocardiogram (BP/ECG) monitor

   c. Lower Body Negative Pressure (LBNP)